Sustainable Development by a Statistical Analysis of Country Rankings by the Population Happiness Level

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Abstract

A statistical analysis of world rankings for the population happiness level was conducted to find ways to stimulate sustainable development. The research is based on data from an annual Gallup World survey called the World Happiness Report. Various data describing the population's happiness level through direct (GDP per Capita, Social support, Life expectancy) and indirect well-being indicators have been studied. The visualization methods, graphical mapping in Cartesian and polar coordinate systems and primary statistical processing of numerical data were used. We have used descriptive statistics, histograms, and cumulative constructions. Linear smoothing was performed, and the GDP per Capita rating trend was used to establish. Since the level of economic development and well-being of the population does not correspond to its happiness, it is recommended to include the implementation of the population's socio-historical, cultural and psychological traditions.

Keywords

Statistical analysis, information technologies, business analysis, sustainable development, country rankings, Russian-Ukrainian war, level of population happiness

1. Introduction

The search for ways for sustainable development becomes relevant with each round of the new wars threats on the planet. The level of happiness of the population is part of the annual Gallup World study called World Happiness Report. Various data describe population happiness through direct (GDP per capita, social support, life expectancy) and indirect welfare indicators. According to the authors' work [1], the happiness rank of the world's countries is called to help government leaders, politicians, and public figures better understand the needs and aspirations of their citizens to improve their well-being and development. This ranking of happy countries considers the cost to the country of economic growth, which is currently taking place in the social sphere, health, environment, and, ultimately, whether this activity brings joy to the individual inhabitant of the kingdom.

The history of country rankings by the population happiness level began in 2006. The British Research Foundation for Economics began calculating the International Happiness Index [2]. Interestingly, GDP figures were not considered in principle in 2006; as they say, in the end, happiness is not in money. Authors [2] looked at three indicators: people's subjective satisfaction with life, life expectancy, and "environmental footprint" - how people affect the environment. The main goal is to show how effectively people in different countries use natural resources for a long and happy life. A total of 156 countries were included in the ranking, and recently the leaders have only changed places, but the essence has remained the same.

The authors of the study [3-4] believe that economic indicators maximally characterize human capital development. Well-known economic indicators include many indicators [5-13]: GDP per capita,

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social support, life expectancy, freedom of life choices, generosity (charity), trust (corruption) etc. The modern economy is trying to explain what factors affect the happiness and well-being of the population [14-25]. No less critical question for economists: when money ceases to matter to people, when the majority of the population receives enough, what else, instead of GDP, what other factors need to be assessed to understand - is the economy developing successfully?

The main goal of this work is to develop a concept of compiling a ranking of the happiest countries based on relevant statistics. The purpose is the following. In this paper, we will try to get a little closer to exploring the data collected in the World Happiness Report and find answers to questions about the factors of the happy development of nations and the secrets of life in the happiest countries. To solve this problem, we need to solve the following subtasks:

- Evaluate the available methods of solving the problem;
- Analyze the advantages and disadvantages of existing solutions;
- Justify the key components of the ranking of countries by the level of happiness of the population.

The solution to the set tasks will have a practical application to stimulate sustainable development. Statistical analysis of world rankings of happiness of the population will be useful to world leaders, modern politicians and prominent public figures, substantiate the key needs of the population as a whole in the country and the desire of each individual to improve their well-being. The received directions of the needs for the happiness of the population of each country will allow to reconsider ways of sustainable development and form the corresponding governmental decisions.

2. Related works

Ideas, implementation, and sustainable development indicators are set out in the 2030 Agenda for Sustainable Development [26-28]. Priorities for sustainable development in the new Agenda included the digitalization and ecologization of society and the development of smart cities [19, 20, 29-41]. Today, the search for sustainable development is at the crossroads between the long-lasting consequences of the Covid-19 pandemic and the new round of full-scale Russian-Ukrainian war in Ukraine. The World Happiness Report may seem inappropriate when children die in Ukraine. The population of Ukraine suffers from the inhuman abuse of the Russian occupiers. According to [42], the World Happiness Report 2022 paves the way for a new future with key knowledge for consumer brands. According to [42], these data point to gaps in our development policies and people's perceptions of their governments' work. The report [43] helps to point out the importance of qualitative development, not quantitative. It considers what people think about women's rights, minority rights, corruption, infrastructure development, education policy, fundamental rights, etc. The use of welfare has always been essential to monitor the quality of life around the globe. In works [44-46], authors considered the main task for most countries was to analyze the well-being of people and use these results to track and explain the quality of life around the world. The primary source of quality of happiness among the population was the organization Gallup, which conducts an annual World Survey. Still, this year the authors decided to use more data to track satisfaction with the COVID-19 pandemic [45]. It is worth noting that it was equally important to study how the geography of the virus and its consequences affect public confidence, social and political status and how the rating is formed due to these factors. The authors [46] also explained the differences between pre-pandemic and viral morbidity rates.

In [1, 4 – 6, 42], especially in the authors of the report Sustainability makes people happy, research finds The World Happiness Report [25] believes sustainable development makes people happier. According to a new study from the University of Oxford, progress towards the UN Sustainable Development Goals includes goals such as adaptation to climate change and poverty eradication [26-41]. According to a study published in Nature Scientific Reports [10], countries with a higher Center for Sustainable Development index have better results in terms of subjective well-being, and Nordic countries have both rankings. As countries become richer, the well-being of their citizens will remain unchanged if further economic growth is not more sustainable, for example, by overcoming inequality, according to [10].

The study also finds that while long-term environmental measures positively impact welfare, some short-term sustainable development efforts may negatively correlate. This connection is partly due to

economic development, as countries with higher GDP tend to consume more due to higher living standards. However, researchers found that low per capita consumption made people less happy even when considering economical development. Researchers have identified several countries that maintain prosperity and work well on sustainable consumption and emission reductions. The World Happiness Report 2021 Media Round-Up on World Happiness and World Happiness Report 2022 was published on March 20, 2021, covering more than 100 news stories worldwide [1]. The 2022 Report [6] shows that Finland has taken the top spot as the happiest country. War-torn Afghanistan, Lebanon, Zimbabwe, Rwanda, and Botswana are at the bottom of the list. The Russo-Ukrainian war escalated in February 2022 after the World Happiness Report data had already been collected. Today Ukraine is in the 98th place in terms of happiness.

3. Methods

To solve the problems, we will use the following methods [47-54]:

- Construction of a mathematical model for data processing - the formation of a file with numerical data in Excel format (text representation)
- Data visualization - a graphical representation with explanatory captions under and in the figures
- Generalization of the data set - calculation of the most common statistical indicators, such as mode, median, scope, arithmetic mean, and others
- Construction of the histogram (as the sample size is sufficient)
- The use of re-smoothing and straightforward methods with Kendall formulas.

4. Experiments and results

In researching the country rankings by the population happiness level, we considered the data [55], which was created to help government leaders, politicians, and public figures better understand the needs and aspirations of their citizens to improve their well-being and development (Fig.1).

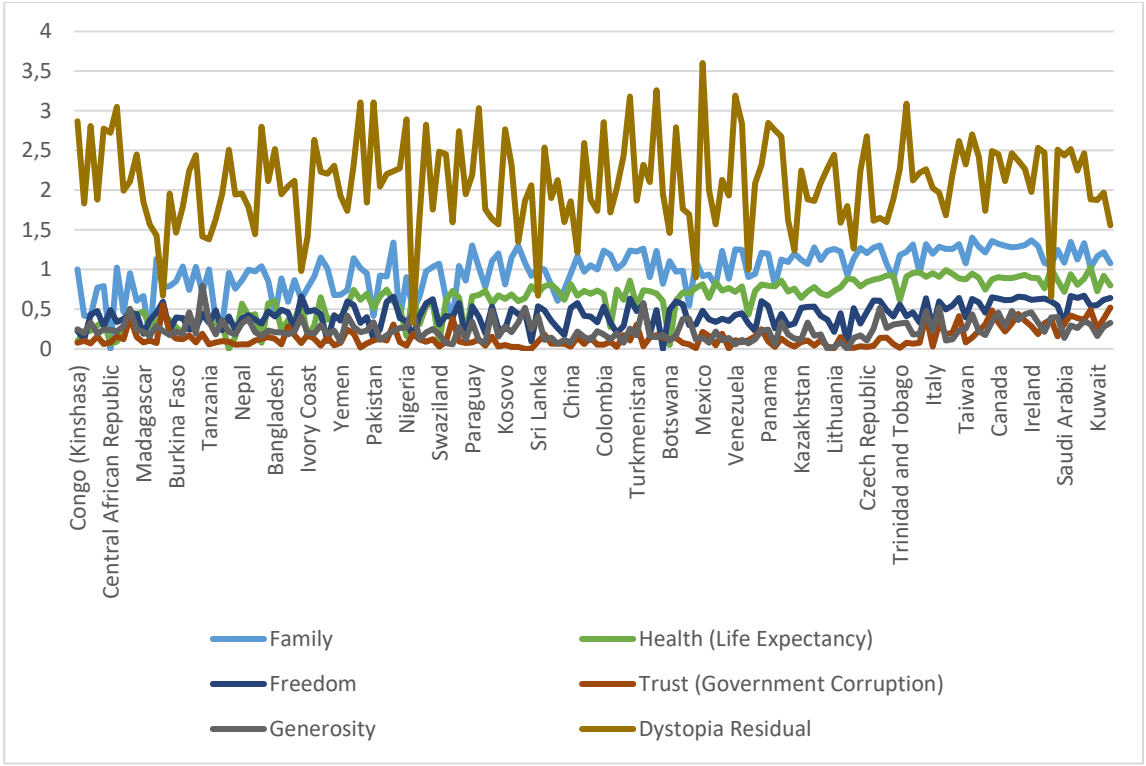
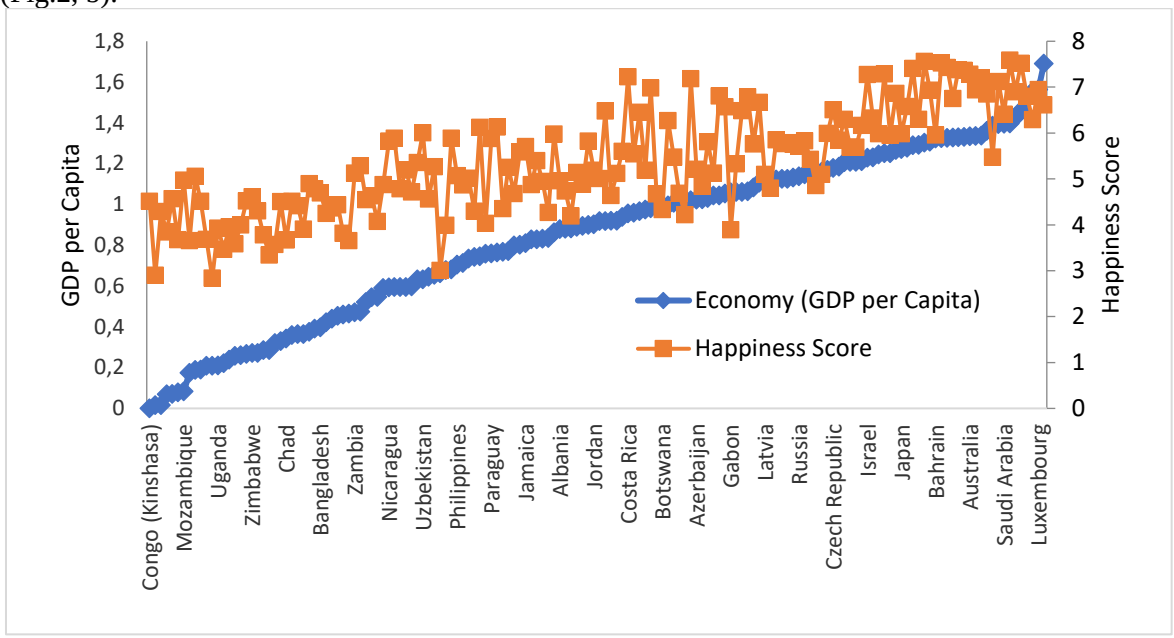


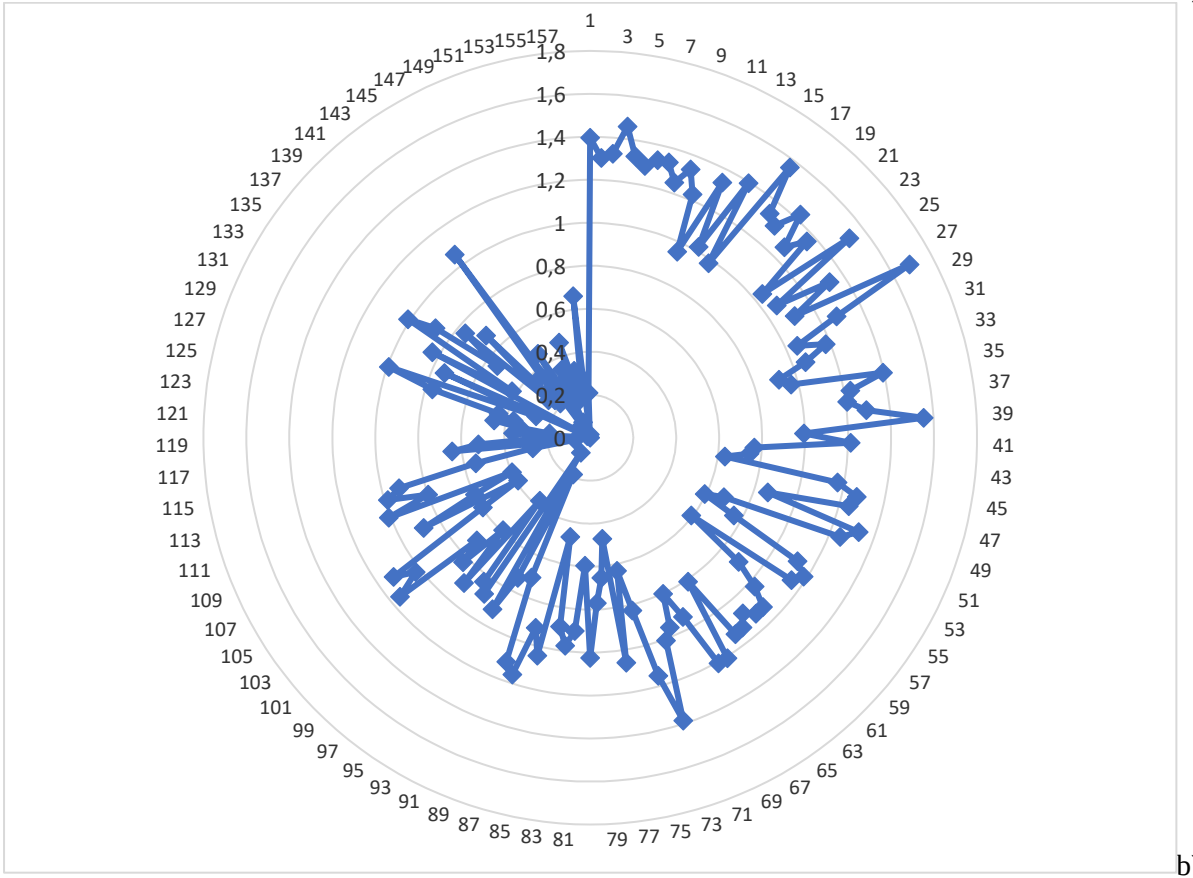
Figure 1: Graphic representation of Happy Planet Index data

The Happy Planet Index (HPI) [55] consists of the following attributes: Country, Region, Happiness Rank, Happiness Score, Standard Error, Economy (GDP per Capita), Family, Health (Life Expectancy), Freedom, Trust (Government Corruption), Generosity, Dystopia Residual (Fig.1).

There are two coordinate systems of data representation called the Cartesian coordinate system and the polar coordinate system chart. The economy (GDP per Capita) and Happiness Score are represented in the Cartesian coordinate system (Fig.2, a), and GDP per Capita – in the polar coordinate system (Fig.2, b).



a)



b)

Figure 2: Graphical representation of the Economy (GDP per Capita) and Happiness Score, where a) - in the Cartesian coordinate system and b) - in the polar coordinate system

The Region means the region the country belongs to. Happiness Rank means the rank of the country based on the Happiness Score. Happiness Score means a metric measured in period by asking the sampled people the question: "How would you rate your happiness on a scale of 0 to 10&". Standard Error means the standard error of the happiness score. Economic (GDP per Capita) means the extent to which GDP contributes to calculating the Happiness Score. Family means the extent to which Family contributes to calculating the Happiness Score. Health (Life Expectancy) means the extent to which Life expectancy contributes to calculating the Happiness Score. Freedom means the extent to which Freedom contributes to calculating the Happiness Score. Trust (Government Corruption) means how Perception of Corruption contributes to Happiness Score.

Descriptive statistics are quantitative characteristics of data [56-70]. The task of descriptive statistics in Excel is to use mathematical tools to reduce hundreds of sample values to several final indicators that characterize the sample [47-54]. The following indicators are used: statistical mean, median, mode, variance, standard deviation, etc. Descriptive statistics of country rankings by the population happiness level are presented in Table 1.

Table 1

The Descriptive statistics of the GDP per Capita of the World Happiness Report

Index	Value
Arithmetic mean	0,846137215
Standard error	0,032070567
Mode	0
Median	0,90198
Standard deviation	0,401843055
Sample Variance	0,162506362
Kurtosis	-0,866986421
Skewness	-0,317574652
Range	1,69042
Minimum	0
Maximum	1,69042
Sum	133,68968
Count	158
Confidence Level (95.0%)	0,063438752

The arithmetic mean (denoted by "Average") measures the major trend that reflects the most characteristic value for a given sample. The formula determines it [47-54].

$$\tilde{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (1)$$

where *n* is the sample size.

The mode (denoted by "Mo") is a meaning found in this series more often than others and is often used for non-parametric data and ranking scales [47-54].

The median (denoted by "Me ") of an ordered series of numbers with an odd number of members is the number written in the middle, and the median of an ordered series of numbers with an even number of members is called the mean arithmetic of two numbers written in the middle. It is a median equation [47-54].

$$Me(n) = \frac{n+1}{2}. \quad (2)$$

The range of numbers (interval) is an indicator that indicates the width of the range of values. It is the difference between the largest and smallest of these numbers. For a more accurate idea of the values variation of the indicator relative to the average, the coefficient of variation is used [71-81].

$$v = \frac{\sigma}{x} \times 100\% \quad (3)$$

Coefficient of Variation (CV) is a relative measure of risk instead of variance and standard deviation. It allows you to compare the risk and return of two or more assets that differ significantly [82-96]. In data analysis, the coefficient of variation is used to compare the scattering of two random variables with different units of measurement relative to the expected value, which allows for obtaining comparable results.

Asymmetry is an indicator that reflects the skew of the distribution relative to the fashion to the left or right. It is the case when any of the reasons contribute to the more frequent occurrence of values that are greater or, conversely, less than the arithmetic mean [71-99]. Lower values are more common for left-handed or positive asymmetry in the distribution than right-handed or negative. Excess is an indicator that reflects the height of the distribution. When any reasons promote the emergence of close to average values, the distribution with positive excess is formed. Suppose extreme values dominate the distribution and, at the same time, lower and higher. In that case, such a distribution is characterized by harmful excess, and in the centre of the distribution may form a depression, which turns it into two vertices. The descriptive statistics analysis tool creates a one-dimensional statistical report containing information about the initial range data's central trend and variability.

The boundary value intervals are indicated, and rectangles are constructed on their basis, the height of which is proportional to the frequencies. The GDP per Capita by country rankings for the population happiness level is shown in Fig.3.

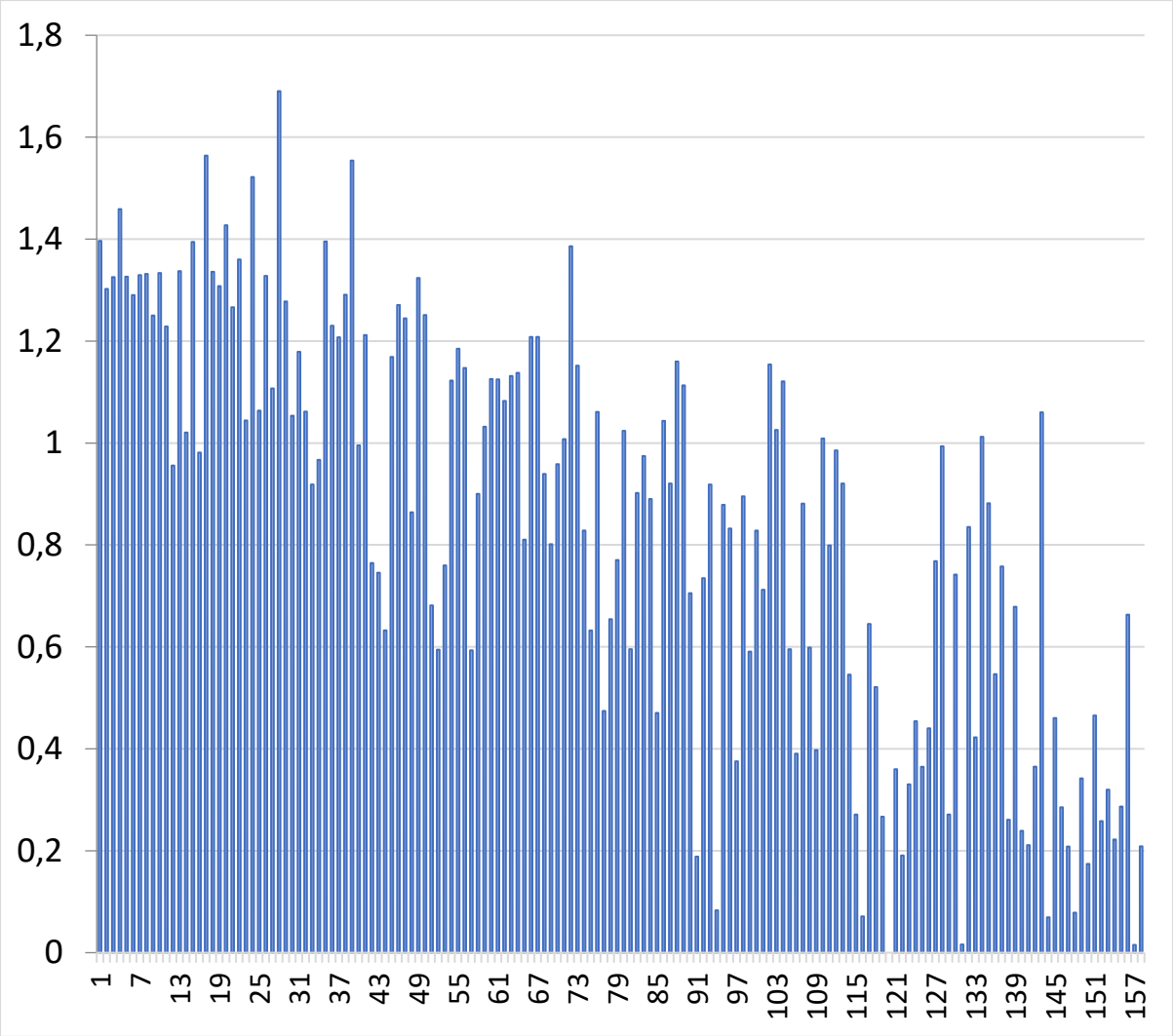


Figure 3: Graphical representation of the economy (GDP per Capita) by country rankings by the population happiness level

The distribution of the feature in the variation series on the accumulated frequencies is represented by the cumulative. The cumulative is built on accumulated frequencies or frequencies. The value of the sign is placed on the abscissa axis. The frequency accumulation is placed on the ordinate axis. In Fig.4, the accumulated frequencies of the economy index are represented by the cumulative. 2. Identifying the trend of the time series by smoothing methods

5. Discussion

5.1. Methods of smoothing time series

A time series is a set of measurements of a variable made over time. A characteristic feature of time series is that observations of an object are carried out sequentially over time.

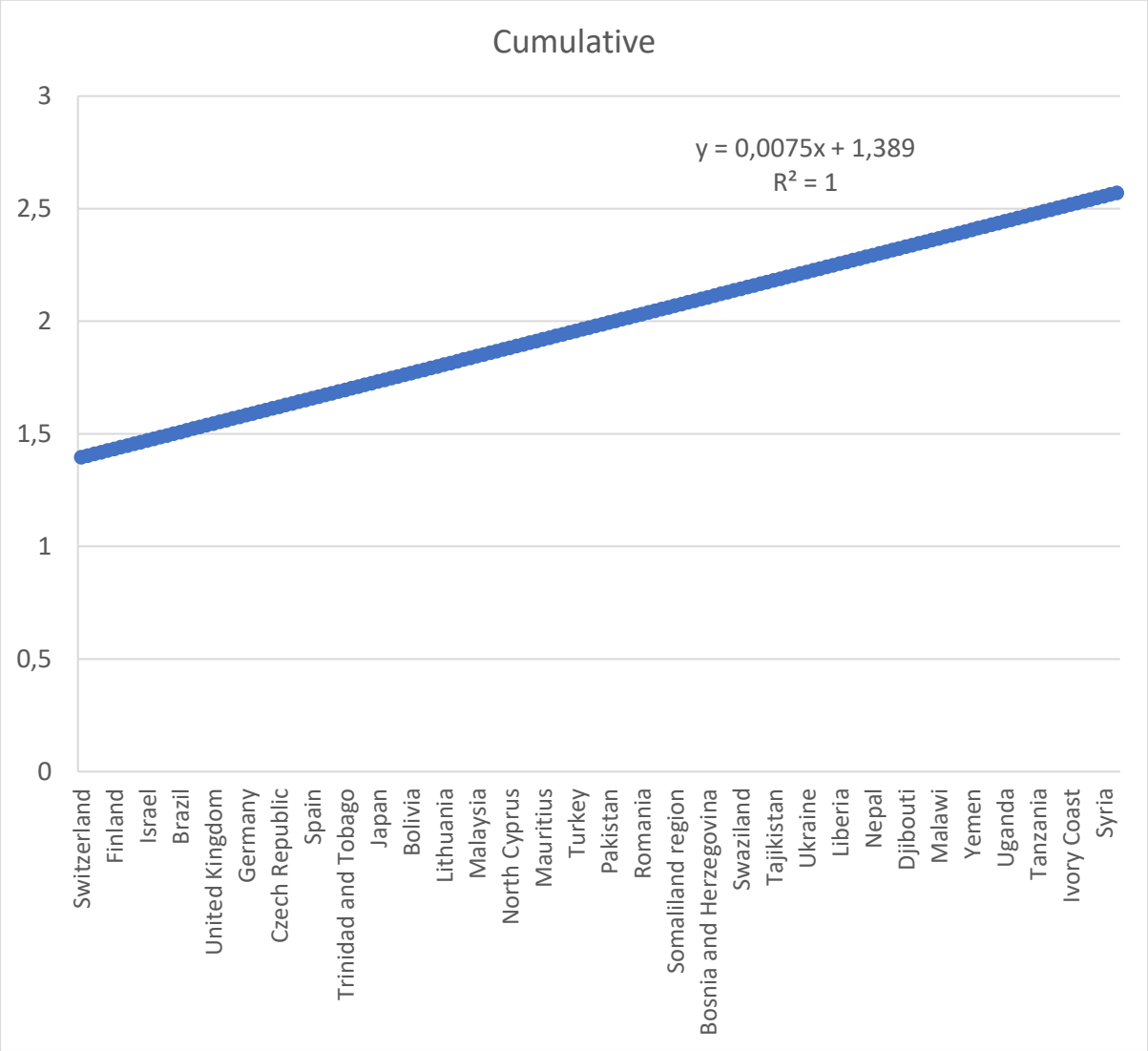


Figure 4: Cumulative of the economy (GDP per Capita) for the different countries ranked by the population happiness level

For the analysis of the time series, the order in the sequence is essential, i.e., time is one of the determining factors. Smoothing methods can be divided into two classes based on analytical and algorithmic approaches.

The analytical approach is based on the assumption that the researcher can set a general view of the function based on visual analysis, believing that its graph corresponds to the nature of the trend.

In other words, the analytical approach replaces the values of time series levels with values theoretically calculated based on the explicit analytical form of the function, which approximates the visually defined trend.

In the algorithmic approach, the appearance of the trend is obtained due to various algorithms that practically implement smoothing procedures. These procedures provide the researcher only with an algorithm for calculating the new value of the time series at any given time t.

The algorithmic approach classifies the following methods: - simple or ordinary moving average; weighted moving average; exponential smoothing; median smoothing.

5.2. Moving average method

The average value of the levels included in the smoothing interval is in problems with a simple moving average. Even when using large smoothing intervals, the effect, in this case, is not very significant. Therefore, re-smoothing is used, increasing the window size for each re-approach. In this case, the effect is significant.

The following table 2 with Kendall formulas implement simple moving averages because, for the smoothing interval in the middle of the time series, which corresponds to the middle column of the table, all weights are 1.

Table 2

The Kendell's formula, or simple smoothing (as example)

Turning point	w=3	w=5	w=7	w=9	w=11	w=13	w=15
FALSE							
TRUE	1,3414366						
FALSE	1,3622666	1,3619					
TRUE	1,3702566	1,3406	1,3470414				
FALSE	1,3585133	1,3460	1,3377842	1,3345755			
TRUE	1,3153266	1,3473	1,3303357	1,3275833	1,3248481		
TRUE	1,3171333	1,3055	1,3314928	1,3193888	1,2847818	1,2974107	
TRUE	1,3037766	1,3070	1,2985742	1,2783111	1,2879554	1,26849	1,285426
FALSE	1,3051566	1,2946	1,2456442	1,2647811	1,2602336	1,2755815	1,2577413
TRUE	1,2707766	1,2199	1,2523557	1,2308088	1,2543709	1,2491015	1,2751806
TRUE	1,1726433	1,2210	1,2082271	1,2423933	1,2230027	1,2571715	1,2758793
FALSE	1,1738660	1,1751	1,2171985	1,2037044	1,2478809	1,2579153	1,2658006
TRUE	1,1045160	1,1873	1,1787785	1,2295044	1,2484736	1,2592669	1,2725326
TRUE	1,2507660	1,1378	1,2116828	1,2390355	1,2463018	1,2667923	1,2709406
TRUE	1,1320960	1,2594	1,2270242	1,2361733	1,2624009	1,2617661	1,2729853
FALSE	1,3132260	1,2592	1,2773157	1,2582511	1,2562909	1,2702223	1,2538206

5.3. Weighted moving average method

The method allows you to describe the primary trend of the series more accurately. When calculating the weighted average of each level of the series within the smoothing interval, it is assigned a certain weight, depending on the distance to the middle of the interval. It differs from the simple sliding method. The levels included in the averaging interval of the weighted average variable and the simple moving average are summed with different weights. A simple moving average considers all levels of the series included in the smoothing interval with equal weights. The weighted average assigns to each level a weight that depends on the distance to the interval middle.

The scales are symmetrical about the mid-level, and their coefficients are determined using the least-squares method (LSM). There is no need to recalculate each time for the series levels included in the smoothing interval, as they will be the same for each position. Also, the weights are always symmetrical

about the mid-level, their sum in the smoothing interval is equal to one, and the positive and negative values of the weights provide the smoothed curve with the ability to reproduce the different curves of the trend curve.

The moving average is not a scalar but a random process. The size of the subset from which the average value is calculated can be both constant and variable.

The moving average may have weights, for example, to increase the impact of newer data compared to older ones. Smoothing the original series gives an idea of the general trend of the series - its trend and a cyclical component.

The result of linear smoothing of the Economy at w = 3 for the different countries ranked by the population happiness level is shown in Fig.5.

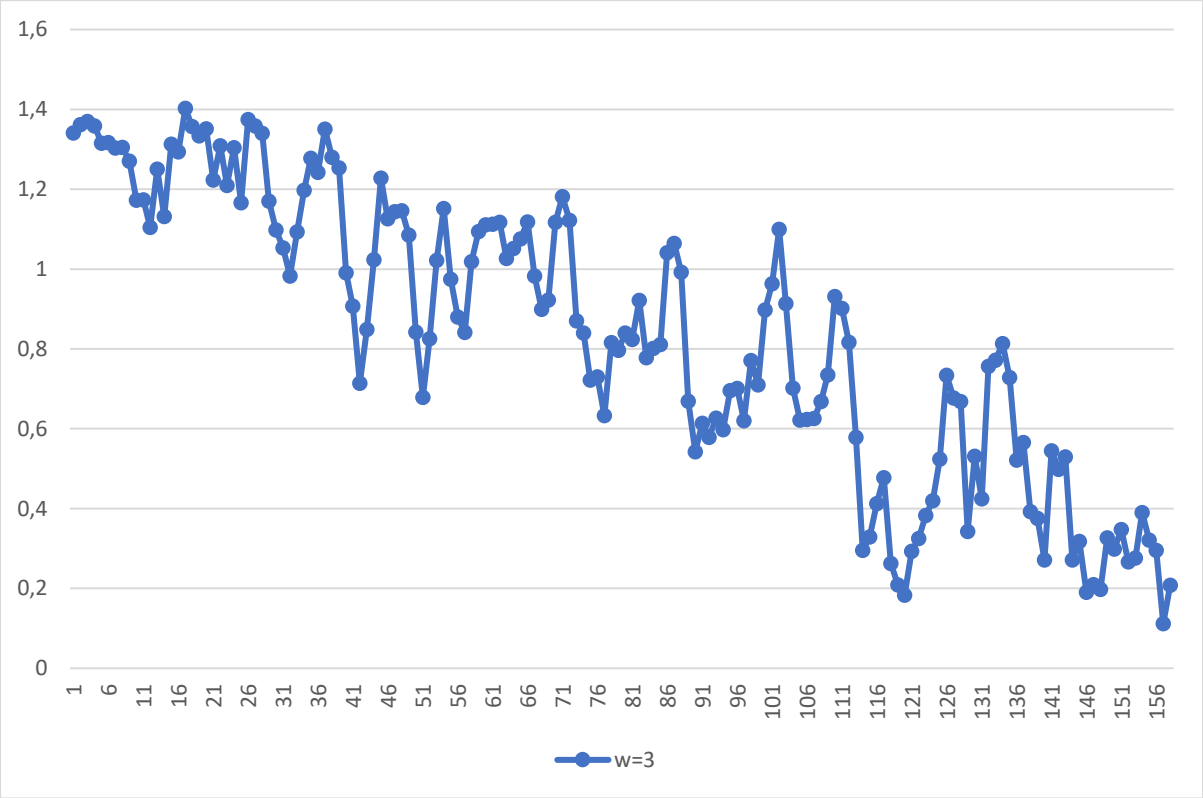


Figure 5: The result of linear smoothing of the Economy at w = 3 for the different countries ranked by the population happiness level

Properties:

1. When using the method of moving averages, choosing the value of the smoothing interval should be made based on substantive considerations and tied to the period of possibly existing oscillatory processes. If the average moving procedure is used to smooth the time series in the absence of any fluctuations, the value of the smoothing interval is often chosen equal to three, five, or seven. The larger the averaging (smoothing) interval, the smoother the trend chart.

2. Neighboring members of a series of moving averages are strongly correlated, as their formation involved the same members of the original series. It may lead to several moving averages containing cyclic components missing in the original series. This phenomenon is called the Slutsky-Yul effect.

3. As a method of averaging, in addition to the above-mentioned conventional arithmetic mean can be considered as weighted moving averages, i.e., when the value of the original series in the smoothing interval is summed with specific weights. Such procedures are appropriate if the change in time series over time is nonlinear.

The result of linear smoothing of the Economy at w = 5 for the different countries ranked by the population happiness level is shown in Fig.6. In Fig.7, we can see the result of linear smoothing of the Economy at w = 7.

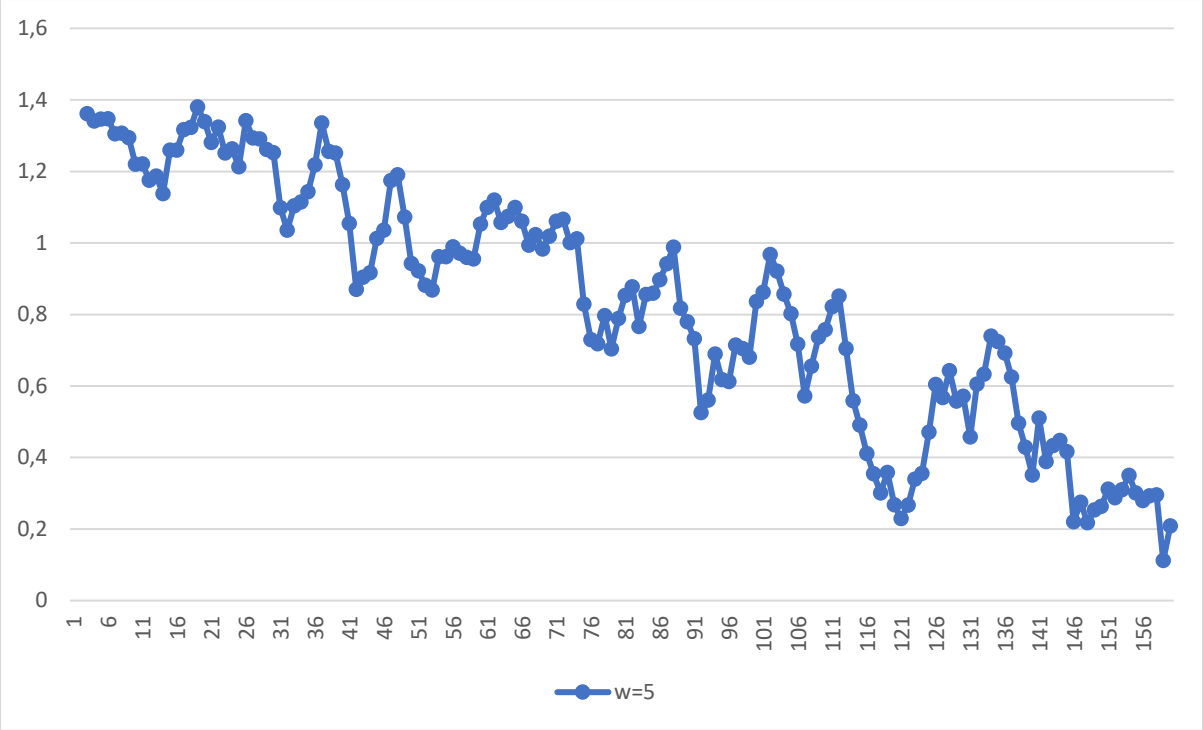


Figure 6: The result of linear smoothing of the Economy at w = 5 for the different countries ranked by the population happiness level

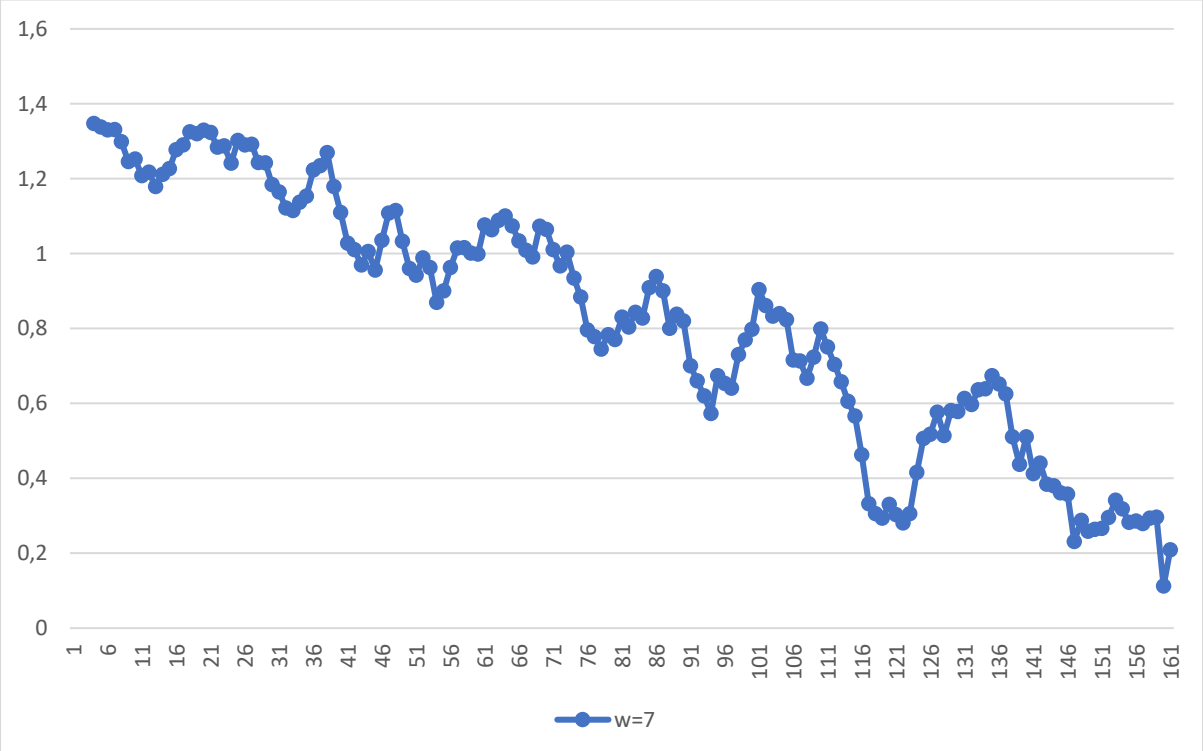


Figure 7: The result of linear smoothing of the Economy at w = 7 for the different countries ranked by the population happiness level

In Fig.8, we can see the result of linear smoothing of the Economy at w = 9. In Fig.9, we can see the result of linear smoothing of the Economy at w = 11.

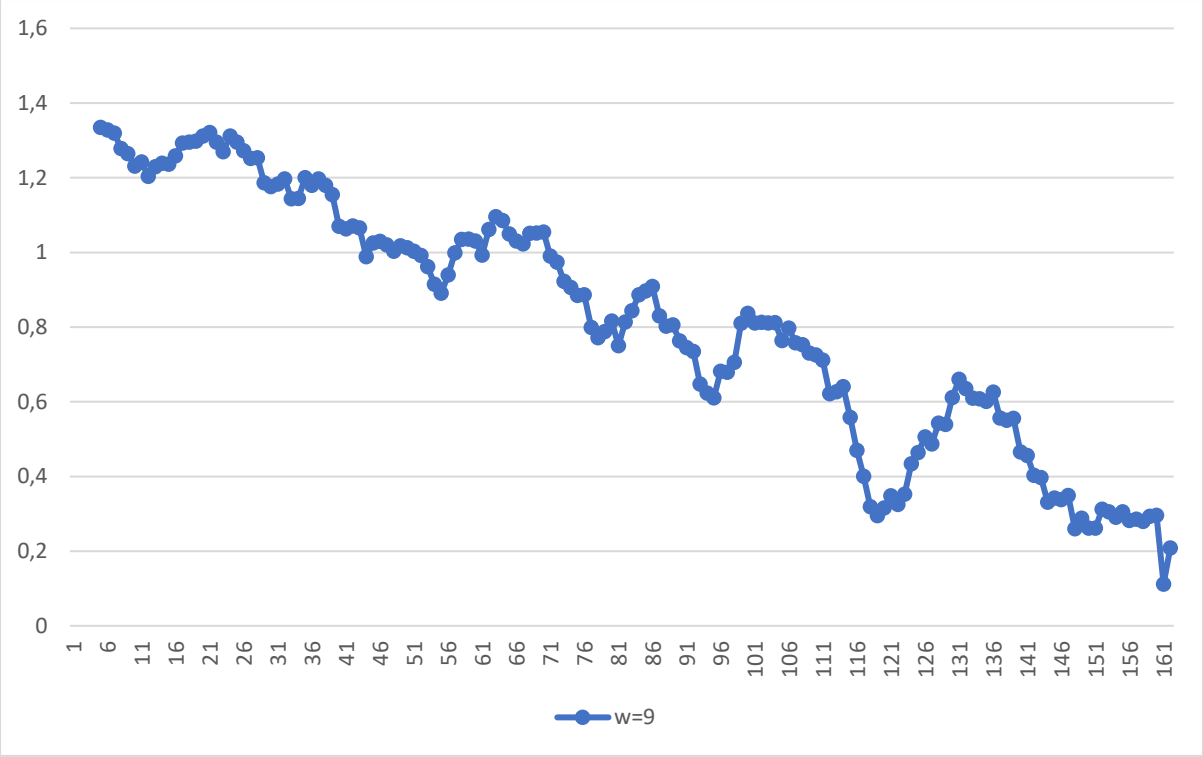


Figure 8: The result of linear smoothing of the Economy at w = 9 for the different countries ranked by the population happiness level

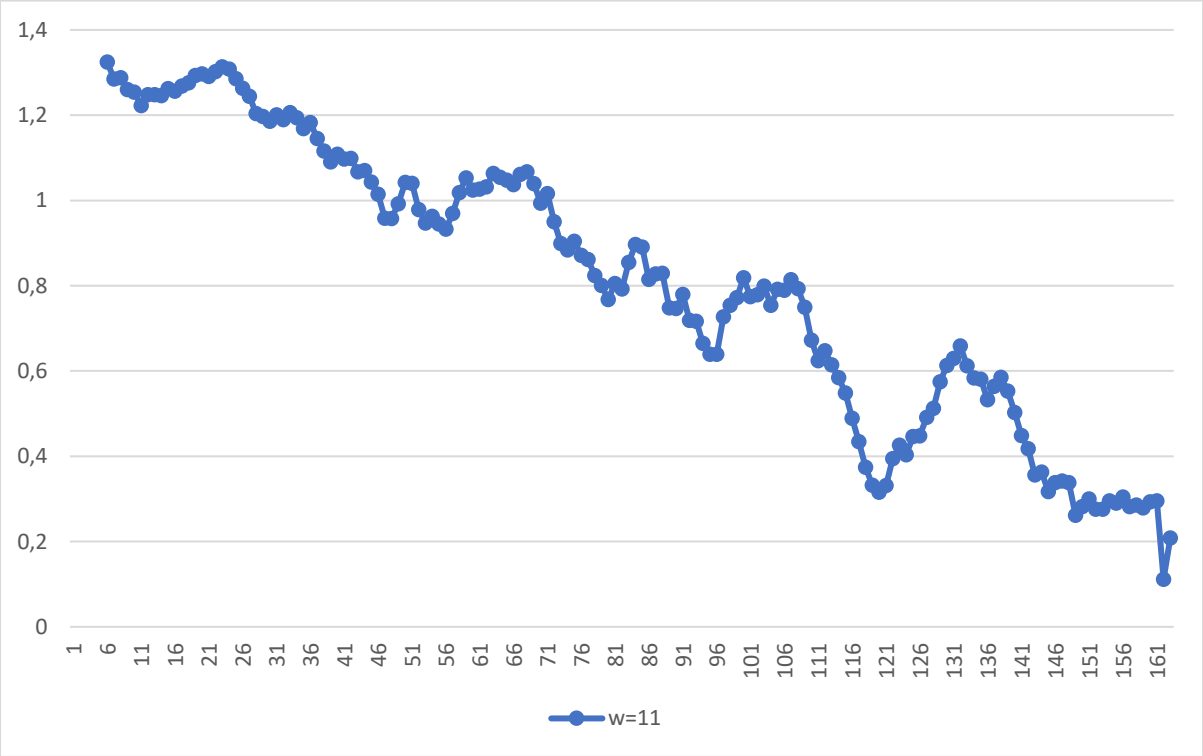


Figure 9: The result of linear smoothing of the Economy at w = 11 for the different countries ranked by the population happiness level

In Fig.10, we can see the result of linear smoothing of the Economy at w = 13. In Fig.11, we can see the result of linear smoothing of the Economy at w = 15.

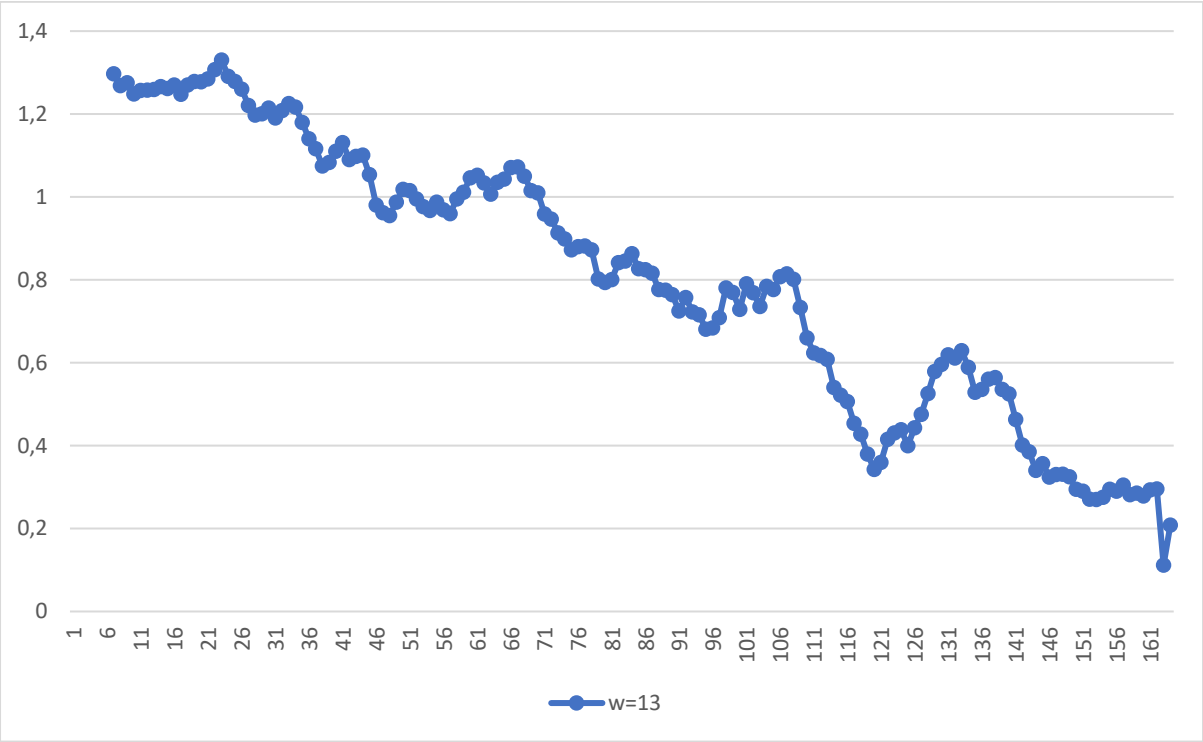


Figure 10: The result of linear smoothing of the Economy at w = 13 for the different countries ranked by the population happiness level

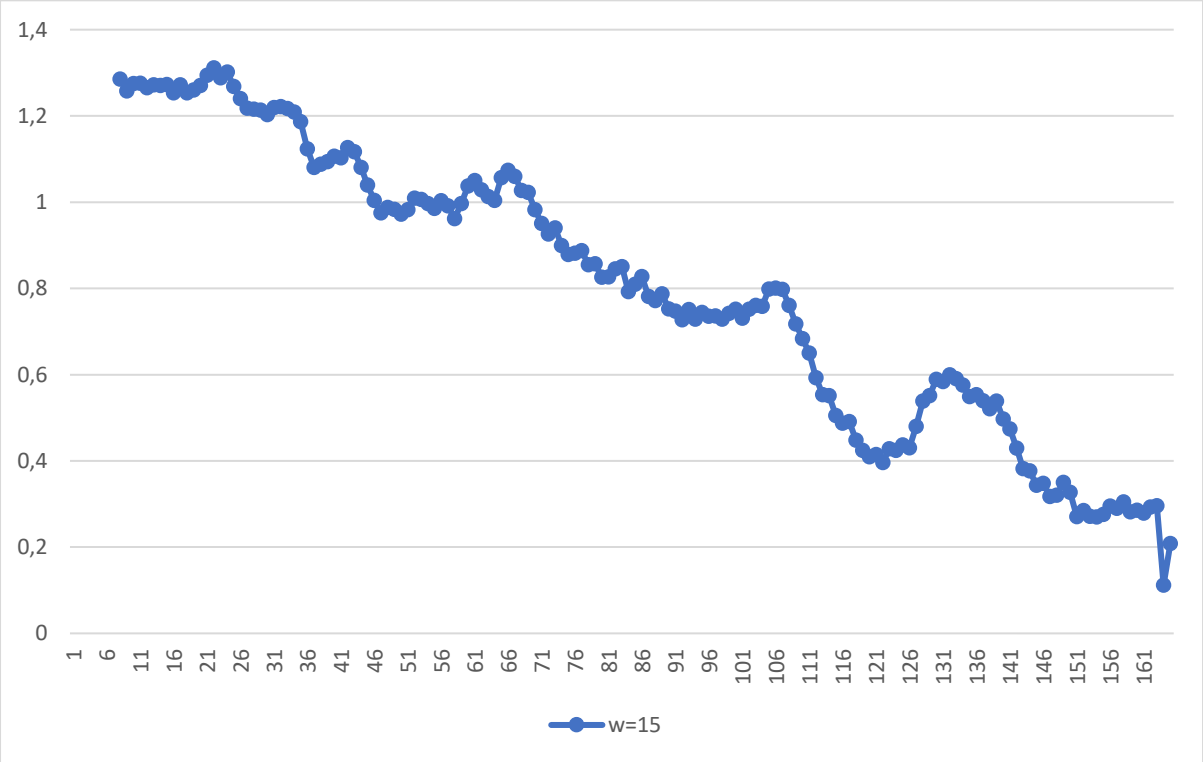


Figure 11: The result of linear smoothing of the Economy at w = 15 for the different countries ranked by the population happiness level

The rationing of time sequences makes it possible to compare the indicators obtained for different objects because, in such rationing, the structure of the series (proportionality between levels in the series) remains unchanged. It makes it possible to compare the calculated indicators and models based

on such data. The most commonly used linear transformation is that the values of the levels of the time series lead to the range of values [0,1], using the following formula [31, 47-53].

$$y_{in} = \frac{u_i - y_{min}}{y_{max} - y_{min_i}}, \quad (4)$$

where y_{in} is the normalized value, y_i is the current level value, y_{min} and y_{max} are the smallest and largest values of a given time series level.

The criterion of efficiency of smoothing of time series is following

1. Criteria for turning points. To assess the smoothing effect, we propose using the criterion of turning points, the content of which is the standard calculation of levels whose values are greater or less than two adjacent.

2. Correlation coefficient. To estimate the closeness of the relationship between the original, we propose using the original series and the smoothed correlation coefficient. The formula for calculating turning points [47-54] is following.

$$IF\ ((I3 > I2);\ (I3 > I4);\ OR\ (IF(I3 < I2);\ (I3\ < I4))), \quad (5)$$

The formula (6) determines the weighted moving average [100-105].

$$WMA = \frac{\sum_{i=1}^{n} P_i * W_i}{\sum_{i=1}^{n} W_i}, \quad (6)$$

where p_i- the value of the price of i -periods; W_i - the value of the scales for the price of i -periods ago.

The weighted moving average is the arithmetic weighted fluctuations of prices over a time period. As an analytical tool, it removes some of the shortcomings of conventional sliding but does not eliminate them.

5.4. Re-smoothing with Kendall formulas

Re-smooth the data using the dimensions of the smoothing interval w = 3, 5, 7, 9, 11, 13, 15 are presented in Fig. 12-Fig.18. The smoothed data for GDP are calculated using to Kendall formulas [100-105] for the smoothing interval w = 3 (Fig. 12), w = 5 (Fig. 13), w = 7 (Fig. 14), w = 9 (Fig. 15), w = 11 (Fig.16), w = 13 (Fig. 17), w = 15 (Fig.18).

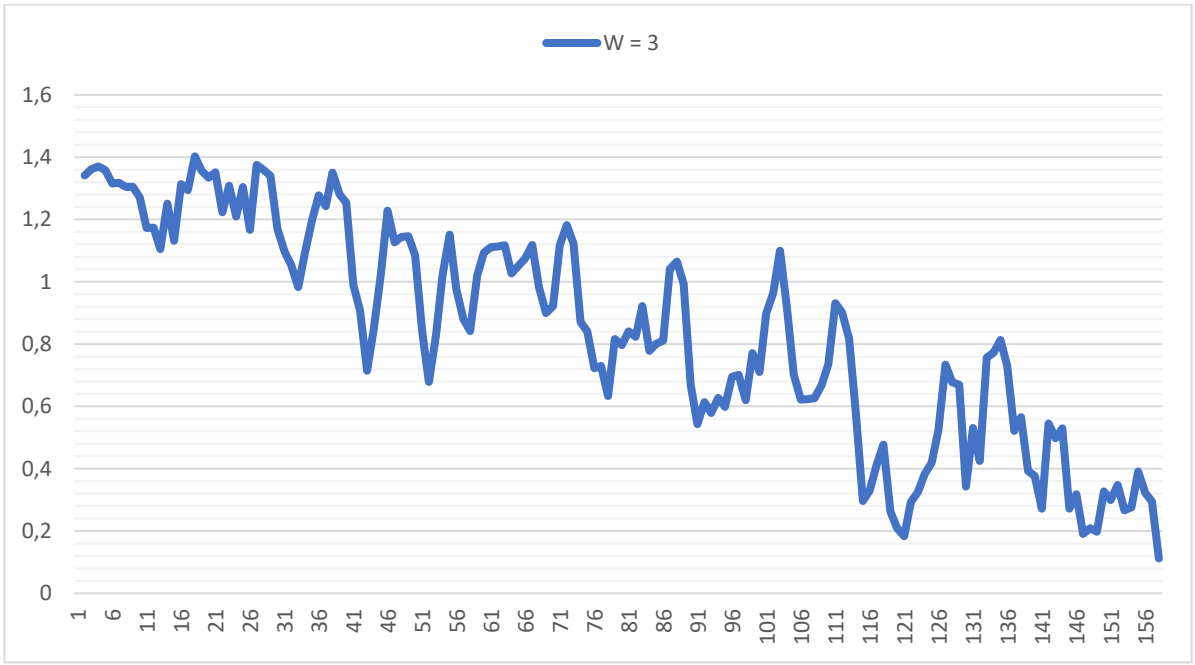


Figure 12: Repeated simple Kendall smoothing and smoothing result at w = 3 for the different countries ranked by the population happiness level

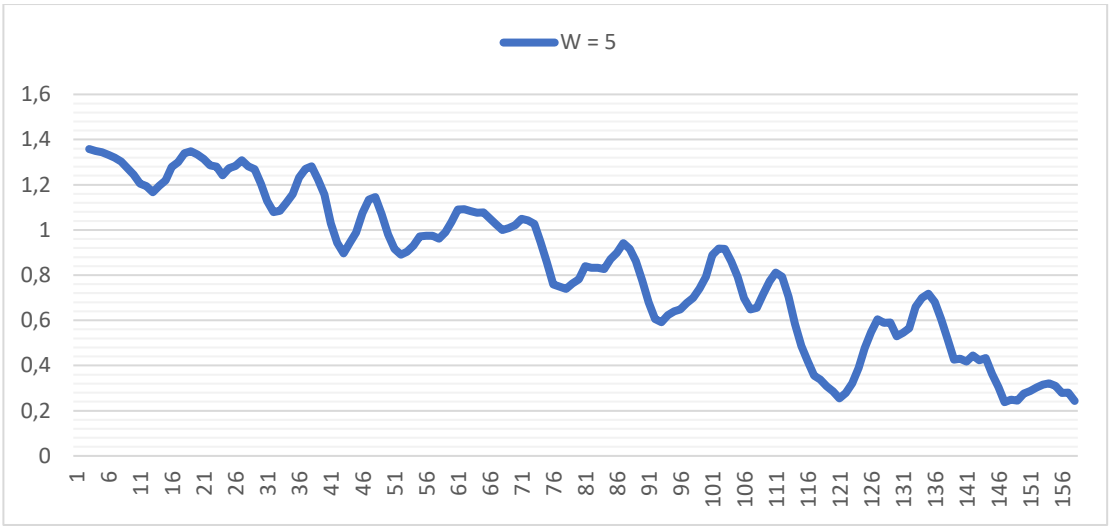


Figure 13: Re-smooth the GDP data using the dimensions of the smoothing interval w = 5 for the different countries ranked by the population happiness level

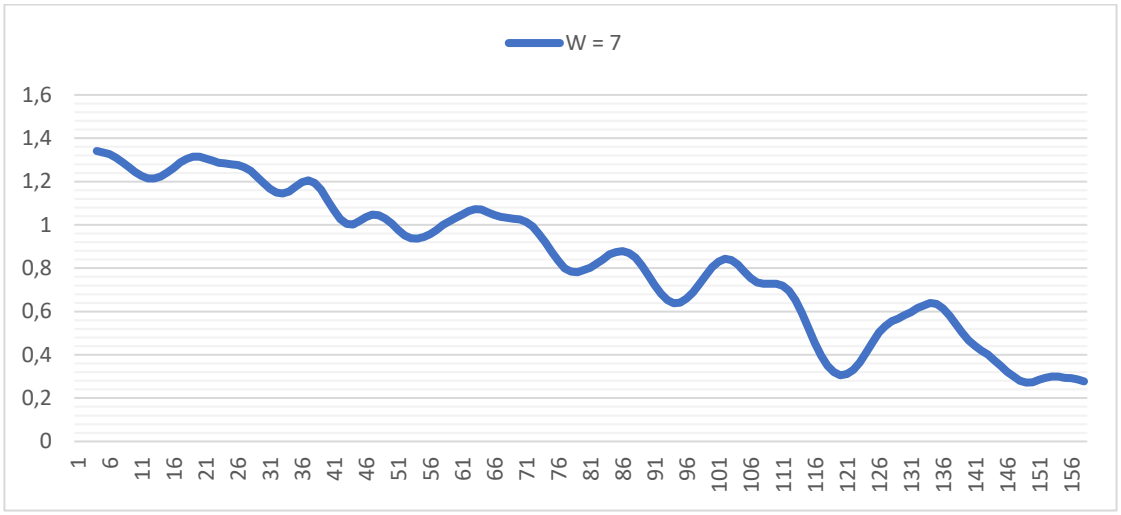


Figure 14: Repeated simple Kendall smoothing and smoothing result at w = 7 for GDP of the different countries ranked by the population happiness level

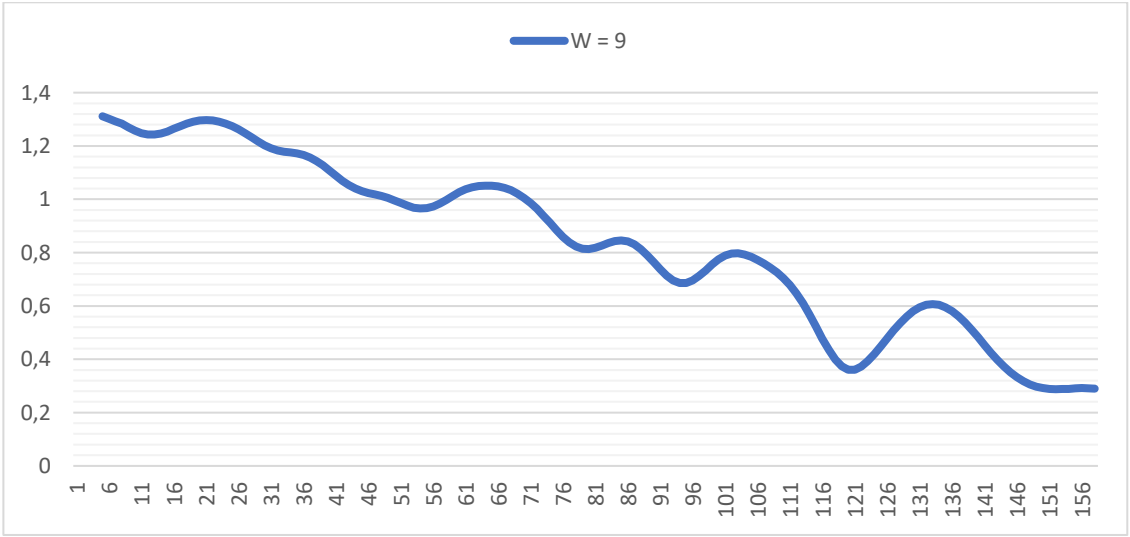


Figure 15: Re-smooth the GDP data using the dimensions of the smoothing interval w = 9 for the different countries ranked by the population happiness level

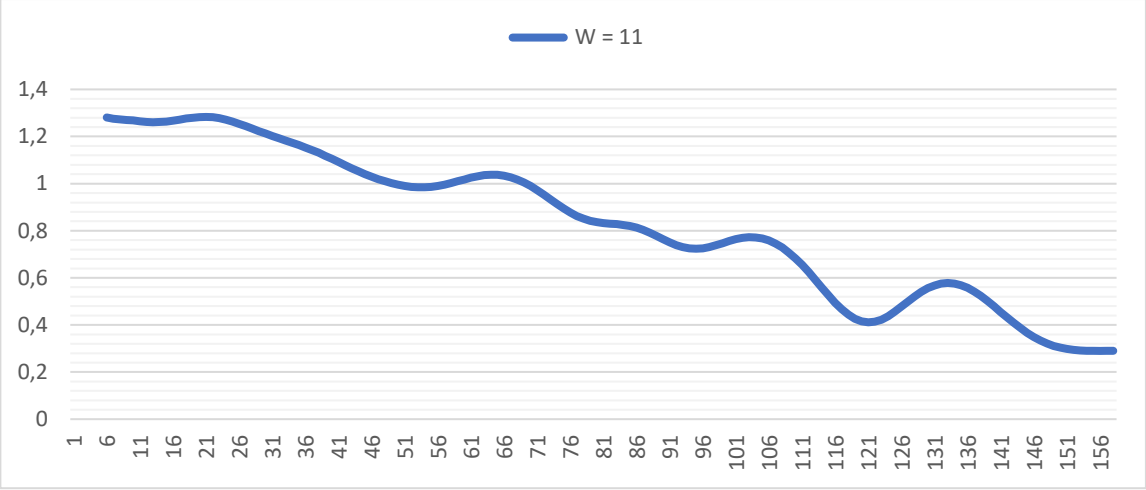


Figure 16: Repeated simple Kendall smoothing and smoothing result at w = 3 for the different countries ranked by the population happiness level

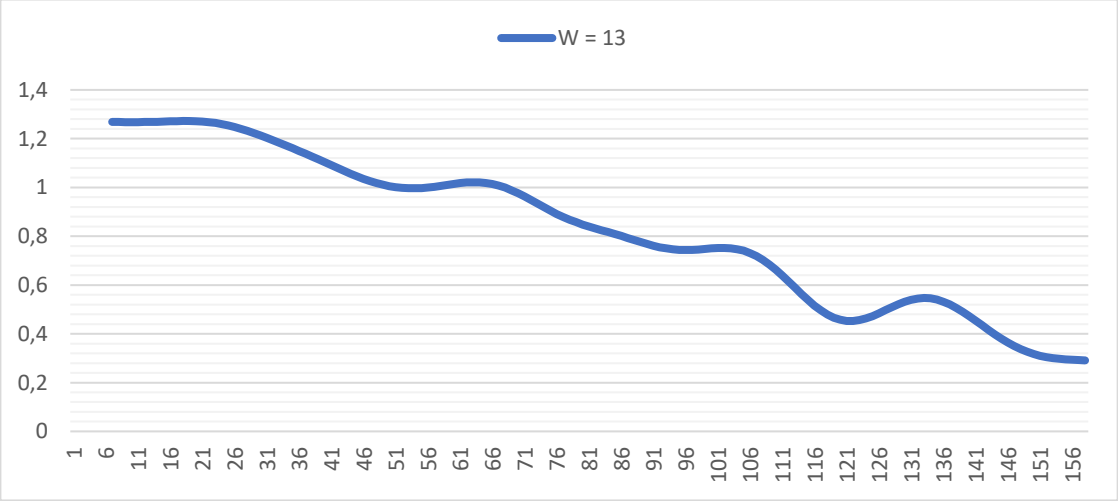


Figure 17: Repeated simple Kendall smoothing and smoothing result at w = 3 for the different countries ranked by the population happiness level

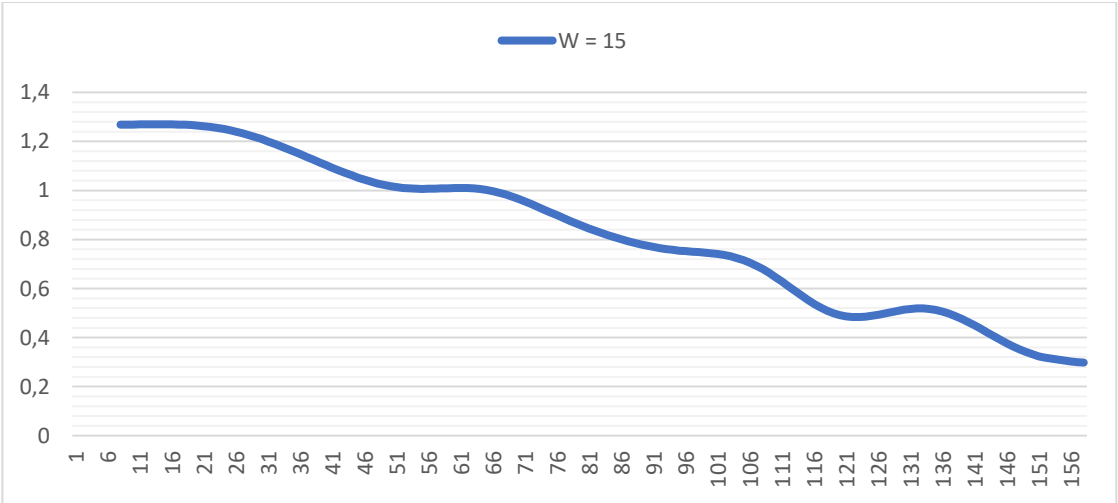


Figure 18: Repeated simple Kendall smoothing and smoothing result at w = 3 for the different countries ranked by the population happiness level

Thus, linear smoothing was carried out to establish the GDP per capita rating trend. Novelty is following. Certain trends and patterns that affect the happiness and well-being of the population have been identified. It is proposed to shift the attention of economists to the importance of qualitative development rather than quantitative. As the level of economic development and well-being of the population does not correspond to its happiness, it is recommended to include the introduction of socio-historical, cultural and psychological traditions of the population in the world. It is proposed to use the obtained results to improve sustainable development goals further and expand them with new value blocks of social responsibility.

6. Conclusions

To find ways to stimulate sustainable development, we conducted a statistical analysis of world rankings of the level of happiness of the population. Various data describing the population happiness level through direct (GDP per capita, social support, life expectancy) and indirect welfare indicators have been studied. Imaging methods, graphical display in Cartesian and polar coordinate systems and primary statistical processing of numerical data are used. We used descriptive statistics, histograms and cumulative constructions. Linear smoothing was carried out to establish the GDP per capita rating trend. Novelty is following. Certain trends and patterns that affect the happiness and well-being of the population have been identified. It is proposed to shift the attention of economists to the importance of qualitative development rather than quantitative. As the level of economic development and well-being of the population does not correspond to its happiness, it is recommended to include the introduction of socio-historical, cultural and psychological traditions of the population in the world. It is proposed to use the obtained results to improve sustainable development goals further and expand them with new value blocks of social responsibility.

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